means should be taken to improve the attendance; and to encourage homework. The polytechnics are to some extent fed by students from these evening classes, and it is of importance that their work should be as serious as possible. Dr. Hoffert is able to report considerable progress in the organisation of higher education in the eastern division of England, especially the increased attention now being paid to the improvement of secondary education. In another place Dr. Hoffert refers to the question of higher elementary schools, and expresses the opinion that schools of this type might very profitably be distributed at suitable intervals over London. "They appear destined to fill an important place in any future organised scheme of elementary and secondary education, and to form the natural completion of the elementary system."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 18.—"Radiation in the Solar System: its Effect on Temperature and its Pressure on Small Bodies." By J. H. **Poynting**, Sc.D., F.R.S., Professor of Physics in the University of Birmingham.

PART I.—*Temperature.*

We can calculate an upper limit to the temperatures of fully absorbing or "black" surfaces receiving their heat from the sun, and on certain assumptions we can find the temperatures of planetary surfaces, if we accept the fourth power law of radiation, since we know approximately the solar constant, that is, the rate of reception of heat from the sun, and the radiation constant, that is, the energy radiated at 1° abs. by a fully radiating surface.[1]

The effective temperature of space calculated from the very uncertain data at our command is of the order 10° abs. Bodies in interplanetary space and at a much higher temperature may, therefore, be regarded as being practically in a zero temperature enclosure except in so far as they receive heat from the sun.

The first case considered is that of an ideal earth, more or less resembling the real earth, and it is shown that the temperature of its surface is, on the average, 325°, 302°, or 290° abs. according as we take for the solar constant Ångström's value 4 cal./min., Langley's value 3 cal./min., or a value deduced from Rosetti's work 2·5 cal./min. The lowest value found, 290° abs., is very near the average temperature of the earth's surface, which may be taken as 289° abs. As the earth's effective temperature must, if anything, be below this, and cannot differ much from that of the ideal planet, Rosetti's value for the solar constant, 2·5 cal./min. or $0{\cdot}175 \times 10^7$ ergs./sec. is probably nearest to the true value, and is therefore used in the following calculations.

The preceding calculations may be turned the other way. It is shown that, on certain assumptions, the effective temperature of the sun is 21·5 times that of the ideal earth. If we consider that the real earth with a temperature 289° abs. sufficiently resembles the ideal, we get a solar temperature $21{\cdot}5 \times 289 = 6200°$ abs.

The upper limit to the temperature of the surface of the moon is determined and is shown to be 412° abs. when no heat is conducted inwards. But Langley finds that the actual temperature is not much above the freezing point on the average. This leads us to the conclusion that it is not higher than four-fifths the highest possible value, the reduction being due to inward conduction.

The temperature of a small body, dimensions of the order of 1 cm. or less, but still so large that it absorbs radiation, is shown to be nearly uniform, and at the distance of the earth from the sun about 300° abs.

Under otherwise similar conditions temperatures must vary inversely as the square root of the distance from the sun. Thus Mars, if an earth-like planet, has a temperature nowhere above 253° abs., and if a moon-like planet, the upper limit to the temperature of the hottest part is about 270°.

[1] W. Wien ("Cong. Int. de Physique," vol. ii. p. 30) has pointed out that Stefan's law enables us to calculate the temperatures of celestial bodies which receive their light from the sun, by equating the energy which they radiate to the energy which they receive from the sun, and remarks that the temperature of Neptune should be below −200° C.

PART II.—*Radiation Pressure.*

The ratio of radiation pressure due to sunlight to solar gravitation increases, as is well known, as the receiving body diminishes in size. But if the radiating body also diminishes in size, this ratio increases. It is shown that if two equal and fully radiating spheres of the temperature and density of the sun are radiating to each other in a zero enclosure, at a distance large compared with their radii, then the radiation push balances the gravitation pull when the radius of each is 335 metres. If the temperature of two equal bodies is 300° abs. and their density 1, the radius for a balance between the two forces is 19·62 cm. If the density is that of the earth, 5·5, the balance occurs with a radius 3·4 cm. If the temperatures of the two are different, the radiation pressures are different, and it is possible to imagine two bodies, which will both tend to move in the same direction, one chasing the other, under the combined action of radiation and gravitation.

The effect of Döppler's principle will be to limit the velocity attained in such a chase. The Döppler effect on a moving radiator is then examined, and an expression is found for the increase in pressure on the front, and the decrease in pressure on the back of a radiating sphere of uniform temperature moving through a medium at rest. It is proportional to the velocity at a given temperature. The equation to the orbit of such a body moving round the sun is found, and it is shown that meteoric dust within the orbit of the earth will be swept into the sun in a time comparable with historical times, while bodies of the order of 1 cm. radius will be drawn in in a time comparable with geological periods.

"The Phenomena of Luminosity and their possible Correlation with Radio-Activity." By Henry E. **Armstrong**, F.R.S., and T. Martin **Lowry**, D.Sc.

The possibility of regarding *luminous manifestations* generally—including radio-activity—as the outcome of oscillatory changes in molecular structure was pointed out by one of the authors more than a year ago in a communication to the Society in which the kind of change contemplated was exemplified by reference to the case of nitrocamphor. As the phenomena of radio-activity are exciting so much interest, it is thought desirable to enter somewhat more fully into an explanation of the argument underlying this conception of the origin of luminous appearances.

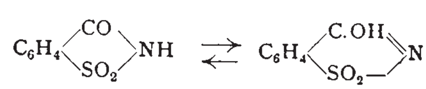
In the note referred to, it was suggested that *tribo-luminescent* substances, *i.e.* substances which become luminous at the moment of crushing, might conceivably, at the same time, manifest radio-activity. Sir William Crookes, at Dr. Armstrong's request, has recently examined saccharin from this point of view.

His remarks are described; they seem to show that saccharin is slightly radio-active towards barium platino-cyanide when crushed. The authors have been unable hitherto to detect any effect on the electrometer.

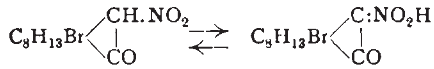
Triboluminescence.—The authors consider the nature of the change involved in the production of the luminous flash, in order that it may be clear why, in their opinion, if radio-activity were observed in such a case, it would have been as the concomitant to chemical change.

There is distinct evidence, they think, that the phenomena of triboluminescence may be correlated with the occurrence of the form of isomeric change which attends the passage of a compound into the isodynamic form of lower potential. Tschugaeff, who has examined more than 500 inorganic and organic compounds, found that about 25 per cent. of the latter gave a more or less intense flash when crushed; of these a considerable proportion appear to be such as could exist in isodynamic forms. Only about 5 per cent. of the inorganic substances flashed.

To take the case of saccharin, the two conceivable forms are:—



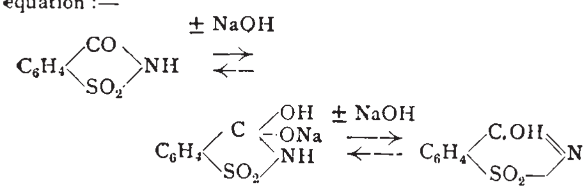
Comparable with these are the two isodynamic forms of – and β-bromonitrocamphor, for example :—



Normal neutral form. Pseudo-acid form.

In the solid state, both forms of π-bromonitrocamphor are stable; when either form is dissolved in a liquid, isomeric change sets in; sooner or later, it may be only in the course of a few hours or even days, a state of equilibrium is established, about 6 per cent. of the material being present in the pseudo form, and 94 per cent. in the normal form. The change, however, does not occur spontaneously, but is undoubtedly dependent on the presence of a catalyst, as equilibrium is established with great rapidity if a trace of alkali be added; acids have only a slight, although definite, accelerating effect. In the case of β-bromonitrocamphor, solutions in benzene of the neutral as well as of the acid form which have been kept during several days without undergoing change, when transferred to another vessel, have rapidly passed to a condition of equilibrium—doubtless because this vessel had been less successfully cleansed than that first used. It can, therefore, scarcely be doubted that the change occurs within a complex system—one which, it is only reasonable to suppose, constitutes an electrolytic circuit. The process is reversed when crystallisation sets in; if the evaporation of the solvent take place sufficiently slowly, the whole of the material is converted into and crystallises out in the less soluble form; if, however, evaporation take place rapidly, the isomeric change may lag behind the crystallisation and both forms may separate. In the case of nitrocamphor, the normal form is the one that separates from the solution; but in the case of π- and β-bromonitrocamphor, although the pseudo form is the minor constituent in the solution, being much less soluble than the isomeride, it is one to separate on crystallisation.

The passage of the one form into the other in the case of saccharin, for example, may be pictured as involving the occurrence of changes such as are represented in the equation :—



Supposing the stable form of lower potential to crystallise out, the crystals, in almost every case, would contain a minute and variable amount of the isodynamic form entangled, as it were, in the mass. In the solid, reversion to the stable form would take place very slowly. Presumably, however, sudden crushing of the crystals would afford opportunity for the change to take place and for the sudden *liberation of energy*—hence the momentary flash.

It is not, at present, necessary to assume that the phenomena are limited to cases of isomeric change; obviously, changes such as those considered may be regarded broadly as dissociative or reversible changes; and from this point of view, it is sufficient to regard the phenomena as the outcome of a loss of potential consequent on the passage from an unstable to a stable system.

From the point of view here advocated, it would be impossible to construct a condenser from a *pure* dielectric; and if the dielectric of a charged condenser were suddenly smashed under suitable conditions, it might exhibit the phenomenon of triboluminosity and perhaps radio-activity.

Fluorescence.—It was originally suggested by one of the authors, in discussing the origin of visible colour, that fluorescence is the "beginning of colour." Subsequently, Dr. J. T. Hewitt, in a paper on the relation between constitution and fluorescence, published early in 1900, took the important step of associating the appearance of fluorescence not with the mere occurrence of the quinonoid type of structure, but with the continued *development* of such a structure—in other words, he has regarded it as the outcome of oscillatory changes in the course of which a non-quinonoid compound undergoes conversion into the isodynamic quinonoid compound.

According to Hewitt, "all the molecules will be undergoing tautomeric change continuously and frequently, and energy absorbed when the molecules have one configuration will be, to an appreciable extent, emitted when they correspond to the other configuration. It is practically certain that the vibration frequency of fluorescein is different in the two states, and hence every opportunity is offered for energy of a rapid vibration frequency to be largely transformed into energy of greater wave-length."

Hewitt obviously does not regard fluorescence as a "flash phenomenon," but as a form of colour, as it were.

While agreeing with Hewitt that the origin of the effect is to be sought in the occurrence of reversible changes involving the production of dynamic isomerides, the authors think that fluorescence is to be regarded as something apart from colour, which, more often than not, is superposed upon colour. The character of the colour effect in fluorescence is quite distinctive; it is not only remarkable on account of its intensity, but there is in it an indefinable qualitative difference which seems to separate it from ordinary colour. If regarded as a "flash phenomenon" this difficulty disappears.

Hewitt appears to regard fluorescence as the outcome of mere intramolecular wobble. To the authors it seems likely that the change is conditioned by a catalyst, and that it occurs within a complex electrolytic circuit.

Phosphorescence.—The phenomena of phosphorescence need to be considered with reference both to cases in which the manifestation attends oxidative or other kinds of chemical change (the glow of phosphorus, the glow-worm, phosphorescent bacteria) and to those in which it is induced by exposure to light (luminous sulphides). The former might well almost be regarded as cases of fluorescence, as a continual supply of energy is derived from the continued occurrence of a chemical change involving loss of energy. With regard to the latter, it would seem that it is not a property of pure substances.

The phosphorescent medium may be pictured as a complex system capable of undergoing "electrolytic" deformation under the influence of light of high refrangibility; as the changes thus induced are reversed, the energy stored up during insolation becomes liberated, and the persistence of the effect is but a consequence of the fact that the change takes place under restraint in a viscous medium.

Dewar's remarkable observations on phosphorescence at low temperatures clearly foreshadow the conclusion that the property is to be correlated with structure.

Radio-Activity.—Pursuing the argument a stage further, it appears to the authors justifiable to regard the activity of radium tentatively as but an exaggerated form of fluorescence in which radiations unnoticed by substances generally—capable of penetrating substances generally—become absorbed and rendered obvious. Such an explanation, from the chemist's point of view, is at least as rational as one which assumes that nature has endowed radium alone of all the elements with incurable suicidal monomania.

There seems to be no good reason for assuming that in fluorescent and other ordinary substances we possess screens capable of arresting rays of every conceivable kind; it may well be that our knowledge of solar radiations is not yet complete.

With regard to "thorium and thorium X," the facts, as stated by Rutherford and Soddy, do not seem to be incompatible with the view that these are but isodynamic forms of thorium or their equivalent, their behaviour being very similar to that of the isodynamic forms of nitrocamphor. In any case, it appears desirable to approach the problem from this point of view, and to investigate the phenomena far more thoroughly on the chemical side.

Whatever the ultimate value of the considerations advanced in the note, they at least serve to show that much may be learnt by further study of the extent to which luminous phenomena generally are to be correlated with structure and structural changes.

July 21.—"On the Oxidising Action of the Rays from Radium Bromide as shown by the Decomposition of Iodoform." By W. B. **Hardy**, F.R.S., Caius College, Cam-

bridge, and Miss E. G. **Willcock**, Newnham College, Cambridge.

A solution of iodoform dissolved in chloroform rapidly becomes purple owing to the liberation of free iodine. This reaction which seems not to have been previously described, takes place in all the solvents tried, namely, chloroform, benzene, carbon bisulphide, carbon tetrachloride, pyridine, amyl alcohol, and ethylic alcohol, but oxygen is always necessary to the change.

The decomposition of iodoform in solution is not, as it at first sight appears to be, a spontaneous change. It is due ordinarily to the action of light. The solvent has a great effect on the rate of decomposition—the solution in chloroform is very sensitive, that in benzene relatively stable. The solution in chloroform furnishes a delicate test for oxygen and for obscure radiations. It suffers change in gas light, faint daylight, and in X-rays or radium rays. The intensity of the action can easily be measured in time units by choosing some standard colour and matching the fluids under examination with it.

The action of light is due to the ordinary light waves, that is to say, any opaque screen completely arrests the action even of sunlight. Solutions in chloroform enclosed in opaque cardboard boxes have remained unchanged near a window for four days.

The action of radium is due to the more penetrating rays. By screening off the various rays, it can be shown that the α rays have no influence—the oxidation appears to be due solely to the β and γ rays, that is, to the negative electrons (β rays) and to the very penetrating ethereal waves (γ rays), which are said to be identical with X-rays. The action of the radium rays, therefore, will take place through as much as 8mm. of lead, though, of course, relatively very slowly, owing to the stopping of the β rays.

Some idea of the intensity of the action of radium may be obtained from the fact that a solution in chloroform in an ordinary test tube is changed to deep purple in twelve minutes by resting the point of the tube upon a mica plate covering 5 milligrammes of radium bromide. Radium rays, however, are much less active than daylight, as is shown by the fact that the more stable solution of iodoform in benzene resists their action for forty-eight hours, though it becomes purple in about fifteen minutes in the least lighted part of an ordinary room. Seeing that the thinnest opaque screen seems completely to stop the active rays of sunlight, it is obvious that sunlight, as it reaches the surface of the earth, can contain at the most exceedingly few β and γ rays.

M. Blondlot has described recently the presence in sunlight of certain rays which traverse metals but are arrested by water (N rays). These rays have no detectable action upon iodoform; the action of sunlight is not delayed appreciably by interposing a water screen many inches in thickness, and the action is completely arrested by even an opaque deposit of lampblack or by aluminium foil.

The fact that light waves [1] exert a chemical activity more intense than that of radium rays compels us for the present to refer the profound, and often lethal, physiological action of the latter to their power of penetration rather than to any novel or peculiarly intense action upon the tissues. They reach parts which ordinarily are shielded by a cuticle impervious to light waves.

One of us has already shown that the α rays profoundly modify the *physical* state of colloidal solutions (*Journal of Physiology*, vol. xxix. p. 29). If the colloid particles be electrically negative, the α rays act as coagulants; if the colloid particles be electrically positive they act as solvents, that is to say, the rays decrease the average size of the particles.

As a provisional basis for the investigation of the physiological action of radium rays, we may therefore regard the α rays as altering the physical state of the living matter, the β and γ rays as altering the chemical processes, especially, perhaps, the oxidation processes of the tissues.

[1] Including, of course, the ultra-violet waves. Hardy and D'Arcy have shown that the production of "active" oxygen by light falling upon a moist surface is limited in the spectrum to rays from the ultra-violet to the blue end of the green (*Journal of Physiology*, xvii. 1894, p. 390).

PARIS.

Academy of Sciences, August 24.—M. Albert Gaudry in the chair.—Batteries with several different liquids, but identical metallic electrodes, by M. **Berthelot**.—Observations of the sun made at the Observatory of Lyons with the Brünner 16cm. equatorial during the second quarter of 1903, by M. J. **Guillaume**. Observations were possible on sixty-seven days during the quarter: the results are given in three tables showing the number of sun-spots, their distribution in latitude, and the distribution of the faculæ in latitude.—On the problem of S. Lie, by M. N. **Saltykow**.—On the Fourier-Cauchy integrals, by M. Carl **Störmer**.—On the function of the metallic core in induction coils, by M. B. **Eginitis**. The effect of the core varies with its shape, material, the temperature of the sparking poles, their nature and explosive distance, and also on the self-induction of the coil.—On the constitution of the phospho-organic acid in the reserve material of green plants, and on the first reduction product of carbonic acid in the act of chlorophyll assimilation, by M. S. **Posternak**. The acid, heated with dilute mineral acids, is quantitatively hydrolysed into inosite and phosphoric acid. From this, and its cryoscopic behaviour in aqueous solution, the formula $O[CH_2.O.PO(OH)_2]_2$, the anhydride of oxymethylene-diphosphoric acid, is given to the substance, and conclusions are drawn from this as to the nature of chlorophyll assimilation.—On the general equation of curves of fatigue, by M. Charles **Henry** and Mlle. J. **Joteyko**.

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